Developing Smartphone Integrated Soil Sensor for African Smallholder Farmers using Artificial Intelligence toward Sustainable Soil Nutrients Management

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About me

• Bachelor and Masters Degrees in **Soil Science** with Specialization in **Soil Fertility and Plant Nutrition**.

• **Research Assistance** in TAMASA project for 4 years

• **Research Fellow** in CDA (an African Centre of Excellence)
Mind the Gaps…

Population, 1800 to 2100
Historical estimates of population, combined with the projected population to 2100 based on the UN's medium variant scenario.

Source: Gapminder & UN Population Revision (2019) Medium Scenario
Note: Historical country data is shown based on today's geographical borders.

Cereal yield, 1961 to 2018
Cereal yields are measured in tonnes per hectare. Cereals include wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, and mixed grains.

Source: UN Food and Agriculture Organization (FAO)
• The low yields obtained in Africa can be attributed to multiple (and often inter-related) factors, however, poor soil fertility and improper nutrients management are the top primary constraints.
Biophysics, chemical and socio-economic factors contributing to low soil fertility and poor productivity in Sub-Saharan Africa

- Low CEC
- Low organic matter
- Low WHC
- Unfavourable pH
- Nutrient toxicities

- Leaching
- Nutrient mining
- Nutrient fixation

- Low inherent fertility

- Low soil fertility

- Weakened ability to maintain fertility

- Low returns on investment in raised fertility

- Traditional strategies undermined or inappropriate
  - Increased pressure on land
  - Lack of labour

- Low access to technology
  - Poor infrastructure
  - Lack of information
  - Weak markets

Adapted from Bationo, (2003)
Way Forward to African Agriculture

Adopting **Sustainable Nutrients Management Strategies** that will

- Use fertilizer more efficiently,
- Increase crop yields,
- Reduce environmental impacts and
- Minimize emissions of greenhouse gases

Several technologies have been developed toward achieving sustainable nutrients management in Africa
Limitations in Current Technologies

- Laboratory Access: Skills & Time, Expensive ($1000/Ha)
- Chemometrics (Dry)
- Soil Test: Wet Chemistry, Dry Chemistry
- Ground Truthing: Diverse Cropping Pattern, Technical Knowledge, Spatial Resolution
- Data Requirement for Model Calibration: NPK only, Skills & Time
- Remote Sensing: STARS/AfSIS, Satellite/UAV
- Crop Models: DSSAT, APSIM
- QUEFTS Model: NE (Maize), AKILIMO (Cassava)
- NPK only: Within Field Variability, Only on Calibration Sites
- Non-Responsive Soil: Data Requirement for Model Calibration

TECHNOLOGY SCALABILITY
KEY MESSAGE!

Previous Researches

Smallholder Farmers

Liebig’s Law of Minimum

Future Research = **HOLISTIC APPROACH**
Soil Diagnosis and Crop Fertilization Technology

1. **What's the problem**
   - Site-Specific Fertilizer Recommendation
   - Crop-Specific Fertilizer Recommendation
   - Optimize Crop Productivity & Soil Health

2. **Current Situation**
   - Very Expensive Soil Diagnosis Method
   - Requires High Technical Know & Time Consuming

3. **Technology Goals**
   - Efficient, Cheaper & Easier Method for Soil Diagnosis
   - Rapid and Convenient Method of Crop Fertilization

4. **Gains**
   - To Reduce Risks, Uncertainties & Production Costs
   - To Maximize Productivity & Maintain Soil Health

5. **Targets**
   - Individual Farmers/Farm Advisors
   - Farmers Cooperatives/Agro-Dealers
   - Sensor Design, Calibration & Development

6. **Milestones**
   - Technology Validation
   - Fields Demonstration

Cam-SISSA (Cambridge Smartphone Integrated Soil Sensor for Africa)
Sensor Design and Fabrication

Smartphone Built-in Sensor

Smartphone Flashlight Modification

Add-on Sensor

Detector

Sample

Sensor Working Principle: Molecular Spectroscopy

Super Process

Results
Sensor Calibration and Validation

- Spectral Unmixing/Processing
- Deep Learning Algorithms

- Spectral Data

- Archived Soil Data (ISRIC, ICRAF, Rothamsted, IITA-ASLAB, CDA-BUK etc.)

- Programming

- Smartphone

- Diverse Cropping System

- Soil Test Standard
- Soil Sensor
- Farmers Practice

- On-Farm Testing/Demonstration

- Nigeria
- Ethiopia
- Kenya
How the Technology will Work!

Spectral Acquisition

- Algorithms

Soil Analysis Results

N, P, K, SOC, S, B, Clay, pH, Zn, Cu, Mn, Fe, Sand etc.

Soil Test-Yield Response Relationship

Crop Suitability

Mono/Intercropping

Long term Weather Data (Rainfall, Temperature & Solar Radiation)

4Rs Nutrients Stewardship
Thank you for your attention!

Questions?